

# Infectious diseases in livestock

**Scientific questions relating to the transmission,  
prevention and control of epidemic outbreaks of  
infectious disease in livestock in Great Britain**

First published July 2002

© 2002 The Royal Society

Apart from any fair dealing for the purposes of research or private study, or criticism or review, as permitted under the UK Copyright, Designs and Patents Act (1998), no part of this publication may be reproduced, stored or transmitted in any form or by any means, without the prior permission in writing of the publisher, or, in the case of photographic reproduction, in accordance with the terms of licences issued by the Copyright Licensing Agency in the UK, or in accordance with the terms of licenses issued by the appropriate reproduction rights organization outside the UK. Enquiries concerning reproduction outside the terms stated here should be sent to the Royal Society Science Advice Section.

The publisher makes no representation, express or implied, with regard to the accuracy of the information contained in this book and cannot accept any legal responsibility or liability for errors or omissions that may be made.

ISBN: 0 85403 579 6

British Library Cataloguing in Publication Data

A CIP catalogue record for this book is available from the British Library

Copy editing by Perfect Page, London, UK; Typeset in Frutiger by Chris Rowland, London, UK;

Proof reading and production management by the Clyvedon Press, Cardiff, UK

Printed by Latimer Trend Ltd, Plymouth, UK

# Infectious diseases in livestock

## Contents

page

<b>Summary and main recommendations</b>	vii
<b>1 Overview</b>	1
(a) Introduction	1
(b) Origins of this inquiry	2
(c) The public background and the possibilities	4
(d) The issues of 'disease-free' status	5
References	7
<b>2 The modern livestock industry</b>	9
(a) General situation	9
(b) Cattle	11
(c) Sheep	12
(d) Pigs	12
(e) Poultry (excluding eggs)	13
(f) Horses	14
(g) Fish farming	14
(h) Exports	15
References	16
<b>3 Infectious diseases of livestock</b>	17
(a) List A and List B diseases and definitions	17
(i) Foot-and-mouth disease	18
(ii) Classical swine fever (CSF)	26
(iii) African swine fever (ASF)	27
(iv) Avian influenza (AI)	27
(v) Newcastle disease	28
(vi) Blue tongue (BT) and African horse sickness (AHS)	29
(b) Diseases affecting the main livestock sectors	30
(i) Cattle	30
(ii) Sheep	31
(iii) Pigs	32
(iv) Poultry	33
(v) Horses	33
(vi) Fish farming	35
(c) Conclusion and recommendations	35
References	36
<b>4 The trading dimension</b>	39
(a) The world trading framework and the role of the OIE and its reference laboratories	39
(b) Trading and 'disease-free status'	40
(c) Trading within the EU	40

<b>5</b>	<b>Surveillance, biosecurity and livestock management</b>	<b>43</b>
	(a) Introduction	43
	(b) The global threat	43
	(i) FMD	44
	(ii) Bluetongue virus	45
	(c) International surveillance	45
	(d) Imports: the rules for trade	46
	(e) Imports: policing the frontiers	48
	(f) National surveillance	49
	(i) Responding to early warnings	49
	(ii) Reducing animal movements	49
	(iii) Surveillance on the farm: the farmer–veterinarian linkage	51
	(iv) Reducing risk on the farm: biosecurity and livestock management practices	52
	(g) Recommendations	54
	References	55
<b>6</b>	<b>Epidemiology, data and modelling</b>	<b>57</b>
	(a) Introduction	57
	(b) Why are some outbreaks difficult to control?	58
	(i) How do outbreaks grow and then decline?	58
	(ii) The problem of early infectivity	59
	(iii) The benefits of decisive interventions	61
	(c) Management and analysis of the data	62
	(i) What can analyses offer?	62
	(ii) Data quality and data management	63
	(d) Data requirements	64
	(i) Case finding and contact tracing	64
	(ii) Livestock demography and farm geography	64
	(iii) Epidemiology of transmission	65
	(iv) Control options, and their likely impact and logistical requirements	65
	(e) Mathematical modelling	66
	(i) Types of model	66
	(ii) Developing and testing models	70
	(iii) Use of models before the next outbreak	70
	(iv) Use of models during an outbreak	70
	(f) Future requirements	71
	References	73
<b>7</b>	<b>Diagnosis</b>	<b>75</b>
	(a) Introduction	75
	(b) The general principles	75
	(c) The specific diagnosis of foot-and-mouth disease (FMD)	77
	(i) Clinical diagnosis in the field	78
	(ii) Laboratory diagnosis of the index case	78
	(iii) Diagnosis during an outbreak	79
	(iv) Surveillance after an outbreak	79
	(d) Improved diagnostics and their potential application to the decentralisation of diagnosis	79
	(i) The need for speed	79
	(ii) PCR methods for the detection of nucleic acid	80
	(iii) Detection of viral antigen and antibody by ELISA	81
	(e) The prospect of novel approaches applied to diagnosis and disease control	81
	(i) Biosensors—general	82
	(ii) Biosensors and FMD	82
	(f) Maintaining a state of preparedness	82
	(g) Integrating diagnosis to rapid response	83
	(h) General conclusions on diagnosis of other List A diseases	83
	(i) Recommendations	84
	References	84

<b>8</b>	<b>Vaccination</b>	<b>87</b>
	(a) Introduction	87
	(b) Elimination of infectious diseases by vaccines	87
	(i) Experience of routine vaccination for FMD	88
	(ii) The immune responses to viral infections	90
	(iii) The immune response to viral vaccines	91
	(iv) The economics of routine vaccination	93
	(v) Key design features of vaccines	94
	(c) Improving routine vaccines for FMD	96
	(d) Emergency vaccination against FMD	97
	(i) The carrier state	97
	(ii) Are carrier animals infectious?	98
	(iii) Discriminating between vaccinated and infected animals	99
	(iv) Efficacy of emergency vaccines in an outbreak	100
	(v) The role of vaccine banks	101
	(vi) Exit strategies	102
	(e) Vaccines against other exotic viral diseases of livestock	102
	(i) High-risk diseases	102
	(ii) Medium-risk diseases	104
	(iii) Low-risk diseases	104
	(f) Recommendations	105
	References	105
<b>9</b>	<b>Dealing with an outbreak: control measures and relevant wider issues</b>	<b>111</b>
	(a) Introduction and background	111
	(i) Ethics and welfare issues	111
	(ii) Environmental issues	112
	(iii) Human health considerations	113
	(iv) Resources	113
	(v) Permanent standstill periods for all livestock	113
	(vi) Increased levels of surveillance on farm	113
	(vii) Technical input to the control of disease	114
	(b) Key control measures that can be applied during an outbreak	115
	(i) Enhanced biosecurity	115
	(ii) Culling	116
	(iii) Emergency vaccination	118
	(iv) Special arrangements—zoos and rare breeds	121
	(v) Requirements at end of outbreak	122
	(c) Control of other diseases	122
	Control measures	123
	(d) Contingency planning	123
	Development of the control policy component within the contingency plan	124
	(e) Recommendations	124
	References	125
<b>10</b>	<b>Research and development, education and training</b>	<b>131</b>
	(a) Research and development	131
	(i) Introduction	131
	(ii) Animal disease research in Britain	131
	(iii) Current provision and issues	132
	(iv) Resources	135
	(b) Education and training	136
	(i) Farmers and livestock keepers	136
	(ii) Undergraduate veterinary education	136
	(iii) Continuing professional development	137
	References	139

<b>Annex A: Terms of reference</b>	141
<b>Annex B: Conduct of the Inquiry</b>	143
<b>Annex C: List of those who gave evidence</b>	147
<b>Annex D: Glossary</b>	157

## Figures

2.1 Maps of livestock distributions in England	9
2.2 Land use in the UK	10
2.3 Value of UK livestock production (£ millions) in 1996 and 2000	10
2.4 Analysis of UK livestock holdings by size and total area	11
2.5 Numbers of livestock holdings, animals and average herd of flock size in the UK	11
2.6 UK livestock numbers in 1967 and 2000	11
2.7 Exports of livestock and livestock products from the UK (£ millions)	15
3.1 The 15 List A diseases and their incidences in the UK	17
3.2 Other notifiable diseases in the UK (excluding those of fish)	18
3.3 Maximum virus excretion/secretion routes in cattle	20
3.4 Most likely method of spread of FMD in each geographic area	21
3.5 Airborne spread of the FMD virus during the 1967–68 epidemic	22
3.6 Movement of FMD-infected animals before 23 February 2001, and locations of implicated markets, abattoirs and dealers	23
4.1 Levels of 'disease-free status' for foot and mouth diseases (FMD)	41
4.2 General conditions for regaining disease-free status after an outbreak of foot-and-mouth disease	41
4.3 Conditions for regaining disease-free status after an outbreak of foot-and-mouth disease.	41
5.1 The spread of Type O pan-Asia strain of FMD virus since 1990	44
5.2 Probability of purchasing one or more <i>Mycobacterium paratuberculosis</i> infected cattle, by number and source of introduced cattle	54
5.3 Probability of purchasing one or more cows persistently infected with bovine viral diarrhoea, by number and source of introduced cows	54
6.1 Local conditions determine the impact of a control policy	59
6.2 Development of virus in blood and breath relative to the appearance of clinical signs for a typical FMD infection in a single cow	59
6.3 The development through time of the number of secondary infections generated from one infected farm	60
6.4 Early and apparently harsh interventions can save animal lives in the long run	61
6.5 $R_0$ map from the 2001 FMD epidemic.	63
6.6 Case histories of the use of models of infectious disease for understanding, planning and predicting	67
6.7 Some uses of models in understanding disease	69
7.1 Methods for virus detection used in human and veterinary medicine	76
8.1 Examples of successful human and veterinary vaccines	89
8.2 Estimated annual costs (£ millions) of routine FMD vaccination in the UK	94
8.3 Exotic viral diseases that pose a threat to UK livestock	103
9.1 The technical input to the decision-making process	115
9.2 Criteria to be taken into account when considering emergency vaccination	120
9.3 Biological properties of other List A viruses threatening the UK	126
10.1 Average number of research publications per year on livestock diseases during 1991–2001	134
10.2 Postgraduate qualifications in selected veterinary subjects, as at 31 December 2001	137

# Summary and main recommendations

## Introduction

- 1 The 2001 outbreak of Foot and Mouth Disease (FMD) in Britain highlighted some major policy issues, which are the subject of numerous inquiries and reports. This report deals, from a scientific standpoint, with how the UK might prevent and combat further invasions of highly infectious livestock diseases, such as those included in List A of the International Organisation of Epizootics (OIE).
- 2 These diseases are serious for animal health and for the economics of the livestock industry. While FMD is not normally fatal to adult cattle, pigs and sheep, it is debilitating and causes significant loss of productivity. In young animals it can be fatal on a large scale. It is one of the most infectious animal diseases, with huge quantities of virus particles being released and the disease spreading rapidly. So it is vital that the UK and its EU partners have a considered strategy for dealing with outbreaks of FMD and other List A diseases, and that this strategy be based on the best available science.
- 3 This report, endorsed by the Council of the Royal Society, was prepared by a Committee comprising scientists, veterinarians, farmers and experts in consumer affairs. The Committee issued a public call for evidence and received some 400 written submissions from individuals, the livestock industry and public and private sector organisations. We visited affected areas in Cumbria, Dumfries and Galloway, and Abergavenny, and held a public meeting in Carlisle. We also took oral evidence from many of those most affected by, or closely involved in managing, the outbreak. We have made the evidence publicly available on the Society's website [www.royalsoc.ac.uk] and on a CD-ROM.

## Ten key findings

- 4 *The overall objective of policy* must be to minimise the risk of a disease entering the country and, if it does enter, to ensure the outbreak is localised and does not develop into an epidemic.
- 5 The UK, and the EU, should seek to retain 'disease-free' status with respect to FMD and the other most serious infectious diseases. Under present circumstances, this status should be

'disease-free without (routine) vaccination'. But this proviso could change if, for example, the risk of an outbreak occurring increased sharply, better vaccines became available or the trading regulations associated with disease-free status were further changed, so it must be kept under active review.

- 6 Better *contingency planning* is vital. The Government must be empowered to act decisively during an outbreak. This requires prior debate about the control measures to be adopted. The Government's Contingency Plans should therefore be brought before Parliament for debate and approval. The Plans should be subject to a practical rehearsal each year and should be formally reviewed triennially to ensure that they take account of: the latest information about the scale of international disease threat; changes in farming practice; scientific and technological developments; regulatory developments at national, EU and global level; and the country's state of preparedness.
- 7 As a result of globalisation, the risk of invasion by exotic (ie non-endemic) animal diseases has increased. It is essential that the UK, and the EU, strengthen their *early warning systems* and ensure that warnings are acted upon. This requires an EU risk and surveillance unit; better funding for the OIE reference laboratories to track disease spread and type the strains; heightened animal disease surveillance on farms; and greater interaction between farmers and veterinarians to improve the effectiveness of national surveillance. Import controls over meat products require tightening.
- 8 *Routine vaccination* against some of the OIE List A diseases is possible. While there are no overwhelming scientific or economic reasons against this approach being adopted we believe that, at present, the considerable technical problems and the trade implications argue against changing current arrangements. Nevertheless it is clear that the long-term solution is to develop a vaccine against FMD (and other diseases such as classical swine fever) that confers lifelong sterile immunity against all strains of the virus. An international research effort is required to develop such a vaccine.
- 9 The *precautionary principle* should be adopted more widely to ensure that any disease outbreak cannot develop into an epidemic. One of the

most effective means of achieving this is to minimise animal movements at all times. The Government should consider a system whereby early warning of infection triggers significantly enhanced precautionary measures.

- 10 Rapid culling of infected premises and known dangerous contacts, combined with movement control and rapid diagnosis, will remain essential to controlling FMD and most other highly infectious diseases. In many cases this will not be sufficient to guarantee that the outbreak does not develop into an epidemic. Given recent advances in vaccine science and improved trading regulations, *emergency vaccination* should now be considered as part of the control strategy from the start of any outbreak of FMD. By this we mean vaccination-to-live, under which meat and meat products from animals vaccinated and subsequently found to be uninfected may enter the normal human food chain. The Government should prepare the regulatory framework and practical arrangements (eg validation of tests, and the supply of vaccines) that would allow this. There must at the outset be an exit strategy agreed among the main stakeholders to allow the country to return to the preferred 'disease-free without vaccination' status.
- 11 The first suspected case in an outbreak must be diagnosed in an approved OIE reference laboratory. Thereafter, *modern diagnostic methods* – including pen-side tests – need to be developed that can shift the burden of diagnosis to veterinarians on the farm. Rapid diagnosis, particularly before clinical signs appear, would limit the size of any epidemic and improve strategic deployment of resources. Such diagnostic methods must be linked by modern telecommunications to central headquarters.
- 12 There is considerable benefit to be gained from understanding the quantitative aspects of infectious disease dynamics. *Quantitative modelling* is one of the essential tools both for developing strategies in preparation for an outbreak and for predicting and evaluating the effectiveness of control policies during an outbreak. A prerequisite is a central database incorporating improved data on farms, the location of animals, animal movements, and the characteristics of the diseases, together with arrangements to input disease control data in a timely and assured way during an outbreak. More work is required to refine the existing models and to strengthen their capacity to inform policy, which in turn requires full access by researchers to this database and to the data on previous outbreaks.

- 13 A national strategy for *animal disease research* should be developed. The overall costs of animal diseases to the UK over the last fifteen years may well have exceeded £15 billion: research is the only rational means available of improving animal health and diminishing disease. The strategy should be delivered through a 'virtual national centre for animal disease research and surveillance' involving the Institute for Animal Health, the Veterinary Laboratories Agency and research groups in universities. It should also involve private research institutes and publicly funded animal disease research being undertaken in Northern Ireland and Scotland.

## Synopsis

### *The modern livestock industry*

- 14 The total value of UK livestock production in 2000 was around £7.5 bn, a fall of over a quarter since 1996. Since 1967 the biggest changes have been a 40% fall in the dairy herd, with a nearly 50% increase in beef. The sheep population has increased by 46% and broiler chickens by 180%, while the laying flock has fallen by about 60%. The average farm size has increased, and there are fewer individual farm holdings. These changes reflect a change in the public's eating habits and the improved efficiency of UK agricultural production.
- 15 Animal movements around the country are considerable and it is easy for disease to spread – as last year's outbreak showed. Ways to minimise movement need to be found, including wider application of 'standstill' quarantine arrangements and ensuring animals are slaughtered as close to the farm as possible.

### *The diseases*

- 16 Domestic livestock have always suffered from a wide range of diseases. As livestock are concentrated in larger and larger numbers, the problems of major epidemics have become more severe. One response was the formation in 1924 of the OIE. The OIE set up an agreed international classification of diseases, with 15 in the most severe List A category and a further 80 in the less severe List B.
- 17 This report concentrates, inevitably, on FMD, but also covers briefly a few of the more severe diseases in the OIE List A affecting each of the main livestock sectors, including: classical swine fever (suffered very badly in the Netherlands in 1998, and in the UK in 2000); African swine fever; avian influenza; Newcastle (poultry) disease; bluetongue; and African horse sickness.



Bluetongue, which particularly affects sheep, is transmitted by midges and is of special concern because of its northward progression, perhaps a result of global warming, which if current trends continue could bring it to the UK.

### ***The trading dimension – the importance of ‘disease-free’ status***

- 18** As a member of the EU and the World Trade Organization (WTO), the UK is bound by the series of rules and regulations of those bodies designed both to protect free trade and to limit the international spread of disease. Central to those rules is the concept of the disease ‘status’ of countries. The UK has traditionally aspired to and maintained the highest level of animal health status, namely ‘Disease free without (routine) vaccination’. This enables the UK to trade with other nations that have a similar status. The evidence and advice we have received confirms our view that the UK should continue to strive for and maintain that status.

### ***Surveillance and early warning***

- 19** The threat of importing disease is high because of: high global demand for meat and meat products; extensive international travel and transport of meat and other foods around the world; improved transport routes; and climate change. A more recent risk is that of deliberate release of pathogens – bioterrorism. To forestall and meet the threat of importing disease, the UK must work with its international partners, both in Europe and more widely, to strengthen the present surveillance and early warning systems managed by the OIE and Food and Agriculture Organisation.
- 20** At the working level, farmers and veterinarians need to be more aware of the risks, and more familiar with the symptoms of rarely encountered exotic diseases. Effective surveillance depends on close collaboration between farmers and their veterinarians, and between them and the State Veterinary Service (SVS). The SVS has become smaller in recent years. Farm animal disease surveillance needs to be strengthened. A major issue remains our poor understanding of how highly infectious exotic diseases are spread locally. This requires resolution through a targeted research initiative with the clear aim of improving standards of biosecurity at the farm level.

### ***Modelling***

- 21** Success in preparing for, and then handling, an outbreak of any infectious disease depends critically on having the right data – eg on the distribution of farms, their sizes and their livestock holdings – and using it effectively. Field epidemiology is essential for the vital detective

work of tracking the spread of infection. Mathematical modelling of infectious diseases should be used between outbreaks to model and help prepare for different outbreak scenarios. Models can also be used when an outbreak occurs to predict the course of the outbreak and to model the effect of different control strategies, and thus to provide input to policy makers about the most effective control strategy for the specific disease and animal species involved.

### ***Diagnosis***

- 22** Because of the speed at which infectious diseases such as FMD can spread, the key to controlling an outbreak is to detect the disease at the earliest possible moment, and thereafter to diagnose infected animals as rapidly as possible. There is a high premium on being able to diagnose a disease even before clinical signs appear.
- 23** Recent developments offer good prospects for a ‘pen-side’ test that could be used by veterinarians in the field. Working devices exist, but still need to be internationally validated and further developed so that they are sufficiently cheap and robust for regular use. When developed they should be linked electronically (eg by satellite link) to a central database that would hold all the results in an outbreak.

### ***Vaccination***

- 24** *Routine vaccination* has played a major role in controlling human and animal infectious diseases. It has led to the eradication of smallpox worldwide and the virtual elimination of rinderpest. There are many animal diseases where routine vaccination is the best control measure, and most animals in the food chain have been vaccinated. Routine FMD vaccination has never been used in the UK, but it was used by many other EU countries until 1991, when it was argued that the disease had ceased to be endemic and the risk of outbreaks had declined to such an extent that it was no longer the most cost-effective way to prevent outbreaks of the disease. The short length of conferred immunity and the large number of FMD strains were significant factors.
- 25** New developments in vaccine research and development should be applied to produce a vaccine capable of conferring lifelong sterile immunity against all strains of the FMD virus. With such a vaccine available it would be possible to change policies radically and introduce routine vaccination for all susceptible species.
- 26** During an outbreak, the short length of immunity conferred by current vaccines is less of

a problem because it is normally still be longer than the outbreak. Moreover, it is clear which specific FMD strain had to be countered. So *emergency vaccination* would be a technical option.

**27** Until recently, the main problem over the use of emergency vaccination has been the difficulty in distinguishing animals that have been infected but then recovered from those that have merely been vaccinated. The possibility of infection from the former is very low, but it led the OIE/WTO to impose a 12 month delay before a country that had used emergency vaccination could regain the status of 'disease free without vaccination'. This compared with a 3 month delay if culling alone had been used, and the additional 9 months delay was why emergency vaccination had always been considered a strategy of last resort. That was why the animals vaccinated in the 2001 epidemic in The Netherlands were subsequently destroyed and did not enter the food chain.

**28** Important advances have taken place within the last year – both technical and in the attitudes of the authorities and consumers – that should allow emergency vaccination to develop into a prime control strategy rather than one of last resort. It is now possible to distinguish vaccinated from vaccinated-infected animals. At its meeting in May 2002, the OIE therefore agreed to reduce the minimum period before a country can reapply for full trade status from 12 to 6 months, only 3 months longer than for culling-only control measures.

**29** The following issues have to be solved before emergency vaccination can be introduced. With significant effort by DEFRA, this should be possible by the end of 2003.

- The policy should be vaccinate-to-live. This will necessitate clear acceptance by all concerned that meat and meat products from vaccinated animals may enter the food chain normally.
- Validation of the marker vaccines to be employed and the tests to distinguish between vaccinated and vaccinated-infected animals, and clear rules for defining the post-surveillance strategy for monitoring herds and flocks.
- Remaining trade implications both within and beyond the EU.
- The precise vaccination strategies to be employed, including the threshold criteria for its implementation when an outbreak occurs and the relative focus upon geographical

regions, high risk farms or species to be vaccinated. Modelling should play a key role here.

- Practical issues concerned with storing vaccines, manufacturing extra vaccine stocks, delivery of vaccines and the training of vaccination teams.

**30** Hence, we believe that the UK should now be planning to use emergency vaccination as an important component of its control strategy for FMD. Culling of infected premises and known dangerous contacts, and any other farms on which evidence of disease is subsequently found, will still be required, but emergency vaccination could be far more appropriate than the alternative of extensive culling.

### ***Dealing with an outbreak***

**31** For the foreseeable future there is no alternative, when an outbreak occurs, to the rapid culling of diseased animals, and all those that are known, or very likely, to have been infected by them. Containing an outbreak rests upon speed of response. In the case of FMD, we envisage the response as involving these first steps.

- On suspicion of disease, impose local movement bans and send the index case to an OIE-reference laboratory for diagnosis.
- If confirmed, impose a national ban upon all livestock movements, standstill arrangements on all susceptible animals bought and sold (if not already in existence), and a 72 hour ban on any movements on and off farms within the restricted infected area by all vehicles and people except in extreme emergency.
- Instigate enhanced biosecurity at all levels, offering advice and support to achieve this.
- Deploy the national structures for handling potential disaster situations, including inter-Departmental coordination and provision of scientific advice and the specific command structures for FMD.
- Cull infected premises within 24 hours and all identified dangerous contacts within 48 hours.

**32** If all these actions are taken rapidly enough, and environmental and farming conditions are favourable, then an outbreak may be contained. This is the historic and, in 2001, the initial approach within the UK. However, for some outbreaks additional measures are needed to stop the disease spreading and to eradicate the virus. In Britain this situation has developed five times over the last 80 years and in all cases the epidemics have proved extremely serious. Until far more is known about the mechanisms of local

spread of the virus only two options exist for the 'additional measures': more extensive culling and emergency vaccination.

- 33** Under a culling-only strategy the aim is to get ahead of the disease by creating a 'firebreak' that will stop the virus spreading and allow the disease to die out. Inevitably this involves culling a larger geographical area than the dangerous contacts alone, and/or targeted culling of farms that are particularly at risk. During the 2001 UK outbreak this was achieved by culling contiguous premises, but in other outbreaks culling has focused on large dairy farms or pig units. If there is a likelihood of significant airborne spread of virus plumes, as occurred in 1967, extensive culling downwind may become necessary. In all these cases large numbers of animals rapidly become involved in the culling policy and major problems develop over logistics. In parallel, difficulties arise because of animals becoming trapped within restricted infected areas: the 'welfare' culls in The Netherlands in 1997/987 and the UK in 2001 were extremely large. Modelling should help to develop culling strategies under a variety of farming and seasonal conditions.
- 34** Emergency vaccination offers an attractive alternative to extensive culling. But, as discussed earlier, its implementation requires a number of issues to be resolved, not all of which are scientific or technical in nature. Once in place, however, we envisage emergency vaccination being employed at an early stage in an FMD outbreak so as to ensure it does not develop into an epidemic. The Government, in collaboration with its EU partners, should put in hand the work necessary to address the related issues identified in paragraph 28 above.
- 35** An exit strategy from each outbreak is necessary. Under a culling-only policy this involves extensive post-disease monitoring of herds and flocks for antibodies against the disease. When emergency vaccination is used, diagnostic tests must distinguish between animals in herds and flocks that have been vaccinated from those that have also become infected. At this stage in the use of emergency vaccination we envisage that any flocks or herds found to contain animals which have been infected would be culled. Some applied research is still needed upon the diagnostic tests but the evidence put to our report indicates they are adequate for the purposes needed. The aim, of course, is to return the country as soon as possible to the status of 'disease-free without vaccination' and full international trading.

## **Research**

- 36** World wide, there is about one-tenth as much research on animal diseases as on human diseases. In the UK its funding from Government has declined, particularly through reductions in applied research commissioned by MAFF/DEFRA. The quality of individual UK groups in general remains world class, and many of the OIE Reference Laboratories are in the UK. But the research is fragmented, and therefore not as effective as it could be. To bring greater coherence to the delivery of animal health R&D, a new National Centre for Animal Disease Research and Surveillance should be established – a 'virtual' centre, organisationally coherent but physically dispersed.
- 37** We support the Curry Commission's call for a new 'priorities board' for research into farming and food matters, and we recommend that DEFRA develop a National Strategy for Research in Animal Disease, to give leadership, direction and coherence to the several agencies involved. This should cover both endemic and exotic infectious diseases.
- 38** An extra £250M is needed over the next ten years for recurrent expenditure to strengthen research groups and to provide expensive large containment animal research facilities. We recommend establishing university-based Research Units in specific areas complementary to those within the Institutes. These Units should be supported long-term (eg 10 years) and be subject to proper levels of funding and strict peer review.

## **Education, training and continuous professional development**

- 39** The Government should work with the professional bodies to improve the education and training of farmers in infectious diseases of livestock and to investigate the subject and skill development priorities in the training of veterinarians.
- 40** Up to date training of veterinarians and farmers, and their continuous professional development, are important elements in disease awareness, prevention and control. We welcome DEFRA's planned review of the effectiveness of training of farmers and land managers, and encourage action to improve their continuous professional development. In its work on veterinary education and training, the Royal College of Veterinary Surgeons should reflect on the experiences of the recent veterinary graduates pitched into dealing with the 2001 FMD outbreak.

## Main recommendations

**41** Our main recommendations are summarised below; additional recommendations are given throughout the full report. The recommendations are addressed primarily to the UK Government. Control of exotic diseases is a devolved matter in Northern Ireland and Scotland and is subject to current discussions with the Welsh Assembly, and many of our recommendations should be read as applying both to DEFRA and to the equivalent ministries in Scotland and Wales. Our terms of reference cover Great Britain only but we hope that this report will be read by the Department for Agriculture and Rural Affairs in Northern Ireland. The regulatory framework for disease control in animals is largely determined internationally – by the EU and, at the global level, by the OIE as part of the WTO framework. Some of our recommendations should therefore be considered also by these bodies.

### Overview

- 42** The UK Government should bring before Parliament for debate a framework for the Contingency Plans covering the principles involved in handling outbreaks of infectious exotic diseases and the resources required for their implementation. (R 1.1)
- 43** The Prime Minister should establish a formal procedure to review at three-yearly intervals:
- the level of threat from imported diseases of livestock;
  - changes in livestock farming practices that could affect vulnerability to disease;
  - scientific and therapeutic advances that could affect policy options;
  - the UK's, and Europe's, state of preparedness. (R1.2)
- 44** The UK should continue to strive for 'disease-free' status against highly infectious diseases such as those listed in the OIE's List A. (R1.3)
- 45** Providing the level of international threat does not increase; there are improved import controls; and there is a demonstrable improvement in the arrangements for handling disease outbreaks, the UK should not adopt a policy of routine vaccination, and should retain the internationally recognised status of 'disease-free without vaccination'. (R1.4)

### Diseases of livestock

**46** DEFRA should:

- undertake a systematic analysis of the information available on the relative threats to the UK from the range of diseases covered here (and other significant disease such as TSEs and tuberculosis), taking account of the impact of globalisation and climate change, in order to set priorities for the national strategy for animal disease and surveillance; (R3.1)
- undertake a comprehensive review of the available information on FMD, and develop a consistent and coherent database of the basic information that would be required during an outbreak; (R3.2)
- carry out urgent research into local transmission of FMD that will improve biosecurity in the field. (R3.3)

### Surveillance, biosecurity and livestock management

**47** DEFRA should:

- propose an EU-wide risk assessment unit and centralised database on surveillance and disease data, and a review of the bodies that provide early warning of animal disease threats; (R5.1)
- promote the speedy implementation of their Action Plan on illegal importing and of a much more coordinated approach at all levels by all bodies concerned with import control; (R5.2)
- investigate all the issues connected with reducing animal movements and come forward with practicable solutions that strike the optimal balance between the legitimate interests of livestock owners, market systems and long-term disease control; (R5.3)
- ensure that all keepers of livestock (including that not kept for food production) are properly registered and submit to DEFRA each year the name of their nominated private veterinary surgeon and a health plan approved by the same veterinary surgeon; (R5.4)
- establish an Applied Research Unit on Livestock Management Practices that will undertake or commission research leading to (i) the design of effective biosecurity measures against infectious animal diseases; and (ii) the design of livestock management structures and practices that improve animal health in terms of infectious diseases. (R5.5)

### Epidemiology, data and modelling

**48** DEFRA should:

- establish a review to determine the data required for informing policy both before and

during epidemics of infectious diseases. This review should involve all those likely to be involved with disease control, including modelling teams, and cover:

- information to be collected on a routine basis, and how this can be kept up to date;
- information to be collected during the outbreak;
- incorporation of the data into a central database;
- use of modern techniques for real time data capture and verification; (R6.1)
- commission research to improve the methodology used to identify dangerous contacts; (R6.2)
- undertake a major research programme into the potential of mathematical modelling for understanding the quantitative aspects of animal disease. Mathematical models can be used both in preparing for outbreaks (including evaluating alternative strategies) and during the course of controlling an epidemic; (R6.3)
- ensure that the data from the 2001 epidemic are checked and then made widely available, while ensuring that any data protection issues are resolved. (R6.4)

## **Diagnosis**

**49** DEFRA should:

- consult with other member states to ensure that the OIE is appropriately constituted to validate new diagnostic techniques and reagents as rapidly as possible; and that OIE reference laboratories are supported politically and financially, so that they can better undertake their national and international obligations, including the development of diagnostic tests; (R7.1)
- ensure that sufficiently specific and sensitive pen-side antigen detection ELISAs are developed for FMD and other major diseases, are validated as quickly as possible, and are available on a large scale for use in the field, and that a similar ELISA is developed especially for detecting antibodies in sheep; (R7.2)
- explore the potential for portable RT-PCR machines for use in the field or at regional laboratories; (R7.3)
- develop advanced telecommunications between the field and central control; (R7.4)
- consider the benefits of bringing responsibility for all List A diseases under a single organisation. (R7.5)

## **Vaccination**

**50** The Government should take the lead in developing an international research programme

aimed at an improved vaccine that would permit routine and global vaccination of livestock against FMD and other List A diseases. (R8.1)

**51** Emergency vaccination should be seen as a major tool of first resort, along with culling of infected premises and known dangerous contacts, for controlling FMD outbreaks. This policy should be vaccinate-to-live, which necessitates acceptance that meat and meat products from vaccinated animals enter the food chain normally. (R8.2)

**52** In determining the arrangements for deploying emergency vaccination, DEFRA should:

- take account of the urgent need to achieve validation for field use of the tests that discriminate infected from vaccinated animals;
- develop emergency vaccination strategies that integrate theoretical and empirical epidemiology and the logistics of delivery of vaccine cover;
- establish an exit strategy that takes account of the need for ongoing surveillance, safeguards for those involved and agreement that products from vaccinated animals can enter the normal human food chain. (R8.3)

**53** DEFRA should explore with the EU and OIE what improvements to vaccines and surveillance tests are required to allow disease free status to be based entirely on surveillance results without the requirement for a minimum waiting period. (R8.4)

## **Dealing with an outbreak**

**54** The main objective in dealing with an outbreak must be to ensure that it does not develop into an epidemic. This requires the following basic measures:

- on suspicion of an outbreak, immediate imposition of strict local movement restrictions and biosecurity measures including culling the animal with clinical signs;
- on confirmation by an OIE Reference Laboratory of an outbreak:
  - mobilization of the full emergency arrangements including all additional logistic resources and the interdepartmental coordination and scientific advisory structure;
  - imposition of a total country-wide ban on animal movement with unambiguous and widely publicised advice on the fate of any animals in transit;
  - rapid culling of all infected premises;
  - identification and rapid culling of all premises where there is a high risk of the disease.

Where these measures are insufficient to guarantee that the outbreak will be contained, we recommend in addition the early deployment of emergency vaccination. (R9.1)

- 55** As a matter of urgency, DEFRA should draw up arrangements for a process for the prior registration for vaccination of zoos and rare breed collections. (R9.2)
- 56** DEFRA should review its arrangements for other diseases, and in particular the developments required to enable emergency vaccination to be used for CSF and Bluetongue. (R9.3)
- 57** The detailed strategies for controlling outbreaks of livestock diseases should be included in the published contingency plan, which should consist of an umbrella plan for matters that are common to all diseases, with specific modules for each disease. These plans should be rehearsed in an annual 'fire drill' that must be realistic and involve DEFRA and all other relevant bodies including MoD. (R9.4)

### ***Research and development, education and training***

**58** The Government should:

- undertake a thorough overhaul of research into animal disease, and in particular develop a national strategy for research in animal disease and surveillance; (R10.1)
- draw together the current research funding in infectious diseases of animals (both endemic and exotic) within England into a single joint arrangement, the funds being made available

to implement the national strategy; (R10.2)

- create a virtual National Centre for Animal Disease Research and Surveillance, the Board of which would be responsible for delivering the National Strategy; (R10.3)
- increase investment in animal disease research and development by the order of £250 million over the next 10 years. (R10.4)

**59** DEFRA should take rapid action to investigate and improve:

- the continuous professional development of farmers and stock keepers;
- postgraduate training in livestock health and welfare;
- the attractiveness of careers within the State Veterinary Service;
- the training of temporary and local veterinary inspectors by DEFRA, with the RCVS, the BVA and its species divisions, investigating the feasibility of the BCVA proposals. (R10.5)